Classification of fluid.

Fluid

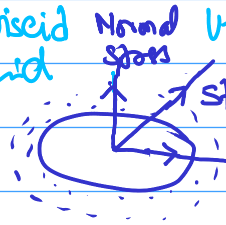
- Ideal fluid — incompressible (non-viscous, homogeneous)
- Real fluid — viscous, compressible, non-homogeneous

Compressibility

- Compressible fluid
  - Gas
  - → Expand by own
  - → occupy whole vessel.
- Incompressible fluid
  - → Liquid (water, oil)
  - → do not expand by own.
  - → occupy definite portion of vessels.

Viscosity

- Inviscid fluid
  - → support only normal stress
  - → water, air
  - ↑ Ideal fluid
- Viscous fluid
  - normal + shear stress both
  - → Syrup
  - → heavy oil
  - → Coaltar
  - → polymer
  - ↑ Real fluid



stress = surface force / area

shear stress

Isotropy

- Isotropic fluid
  - a fluid property is at a point same in all dir
- Anisotropic fluid
  - not same in all dir

w.r.to a property of fluid.

Newton's law of viscosity

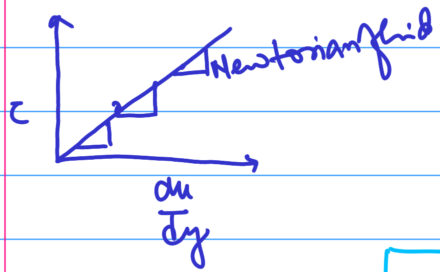
Shear stress ∝ shear strain

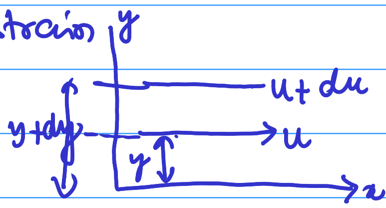
$$\tau \propto \frac{du}{dy}$$

or

$$\tau = \mu \frac{du}{dy}$$ — Newton's law of viscosity

μ — constant : coefficient of viscosity





- Newtonian fluid
  - water
- Non-newtonian fluid
  - Elastic body
  - Bingham plastic
  - pseudo plastic
  - Dilatant fluid

Syllabus → unit 1, 2, 3 → Inviscid fluid
4 → viscous fluid

Compressible fluid	Incompressible fluid
do volume change under action of pressure	volume do not change
density is variable	density is constant

Properties of a fluid:

density, specific volume, viscosity, pressure, temperature

Motion of fluid : velocity, acceleration

Independent variable $\vec{r}, t$ → (x, y, z) at time t $P(x,y,z)$

Dependent variable → properties of the fluid and velocity, acceleration

$\vec{q}$: velocity $\vec{q} = \vec{q}(x, y, z, t) = \vec{q}(\bar{r}, t)$

ρ : density $\rho = \rho(x, y, z, t)$

Motion of fluid is studied in term of flow variables (velocity, density, pressure, temperature – unknown variable) as a function of space and time

$\bar{q} = \bar{q}(\vec{r}, t)$, $p = p(\bar{r}, t)$

$\rho = \rho(\bar{r}, t)$ $T = T(\bar{r}, t)$

Derivation and solution.

Tools. to find flow variables at each position and time, we have to learn about following equations

Coupled non-linear PDEs.

→ Equation of continuity $\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{q}) = 0$ — ①

→ Eqⁿ of motion — $\frac{d\vec{q}}{dt} = \vec{F} - \frac{1}{\rho}\nabla p$ (Inviscid fluid) — ②

$\frac{d\vec{q}}{dt} = \vec{F} - \frac{\nabla p}{\rho} + \nu \nabla^2 \vec{q} + \frac{1}{3}\nu \nabla(\nabla \cdot \vec{q})$ (viscous fluid) — ③

→ Eqⁿ of energy:

$\rho \frac{d}{dt}\left(\underbrace{e}_{\text{internal energy}} + \frac{1}{2}q^2\right) = \nabla \cdot (\underbrace{\overleftrightarrow{\sigma}}_{\text{viscous tensor}} \cdot \vec{q} - \underbrace{\vec{Q}}_{\text{heat Conduction}}) + \rho\, \vec{q} \cdot \underbrace{\vec{F}_b}_{\text{body force}}$ — ④

for perfect gas $e = \underbrace{c_v}_{\text{specific heat}} T$

→ Eqⁿ of state. $pv = RT$ (for perfect gas fluid)

In this semester, we have to study about derivation of eqⁿ ①, ② and ③. and their solution is simple problems.

Two approach of study of fluid motion.

Read about →

Lagrangian approach — particle ← fix — point — Eulerian approach

Read about → Continuum model

we discuss about these topic #.